Editorial: Modeling and control of mechanical/ biomechanical systems

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Many modern control applications are interdisciplinary in nature. Variety of disciplines are oriented on application of control theory and modeling of mechanical/biomechanical systems to solve practical problems in their specific fields. Bearing this in mind, there are included in this special subject some interesting contributions covering different areas such as bifurcations and chaos in dynamical systems, stability of dynamical systems, original numerical methods of vibration analysis, non-smooth systems, engineering systems and differential equations, control in dynamical systems, asymptotic methods in nonlinear dynamics, vibrations of lumped and continuous systems, dynamics in life sciences and bioengineering. A brief description of contents of this special subject is as follows:

Analytical study of the two degrees of freedom nonlinear dynamical system is presented by J. Awrejcewicz and R. Starosta. Internal motion of the system is separated and described by one fourth order differential equation. An approximate approach allows for reduction of the problem to the Duffing equation with adequate initial conditions. There is a novel idea for an effective study of nonlinear dynamical systems consisting in a concept of the socalled limiting phase trajectories. Important nonlinear dynamical transition type phenomena are detected and discussed. In particular, nonsteady forced system vibrations are investigated analytically.

For selected private reactions, J. Awrejcewicz et al. conducted experiments devoted to mechanisms of complex chemical reactions. It caused a problem of identification of kinetic parameters, because the same set of rate constants must describe both public and private reaction stages, and even the general mechanism. Solution of this problem for a reaction of olefins hydroalumination is successfully proposed, and in order to optimize the computational process, a methodology of parallelization is elaborated.

The control design of underactuated robots usually relies on partial feedback linearization based techniques which are exclusively developed for systems modeled by independent coordinates. L. L. Kovács and L. Bencsik propose an interesting control algorithm formulated by using dependent coordinates. The applied computed torque controller is realized by introduction of actuator's constraints that complement the kinematic constraints. They are used to describe the dynamics of the investigated service robotic system in relatively simple and compact form. The proposed controller is applied to the computed torque control of the planar model of the acroboter service robot.

V. F. Duma considers the problem of command functions of galvanometer-based scanners which are necessary to produce their linear plus parabolic scanning functions. He completes some theoretical aspects with the experimental study of the most useful scanning functions of

the galvanometer-based scanners with applications in biomedical imaging, in particular, in Optical Coherence Tomography demonstrating that the triangular function is always the best one for applications from an optical and a mechanical point of view. In the study, the input voltage/command function which should be applied to the galvanometer-based scanner to produce the desired triangular scanning function with controlled nonlinearity for the fastest possible stop-and-turn portions is determined analytically in relationship with the active torque that drives the device.

C. Erazo et al. analyze an extended state observer involving a continuous non-smooth structure. Their study of the observer's dynamics requires to use advanced mathematical tools from the analysis of nonlinear systems. The sufficient conditions for absolute stability of the extended state observer are established. Based on the provided study, a methodology to estimate several nonlinear functions in dynamics systems is proposed.

Active control system that counteracts the development of chatter vibration is proposed by M. Hoffmann et al. The vibration amplitude depends on the dynamic properties of the machine tool cutting a work-piece that causes lost of machining stability. The proposed active control system employs electromagnetic or piezoelectric actuator to suppress vibration during milling. The control strategy introduces damping into the system, thereby raising the critical depth of cut and reducing forced vibration amplitude. It enables stable cutting under a much wider range of cutting parameters while comparing with the uncontrolled system. Cutting tests are performed on JAFO FYN-50 machine with mill DIN 845 B-25 K-N HSS to demonstrate an effectiveness of the proposed systems.

The main task in modern self-propelled antiaircraft guiding systems is to automatically detect and track a target during carrier-vehicle movement. This task is solved by I. Krzysztofik and Z. Koruba. A pre-programmed launcher control during target searching and a corrective control of the launcher during tracking of detected target is the key point of the solution. Kinematical influences resulting from surface obstacles negatively influence operation of the launcher causing deviations from target's position. An adaptive control should be employed, because of an accurate operation of guiding system, it is necessary to adjust the launcher control parameters to notoriously change operative conditions. Their paper presents the special adaptive control algorithm for launcher mounted on a mobile base. The algorithm is based on a nonlinear object-control procedure where object properties are mostly unknown, and the object is under the influence of external interferences.

Effects of synchronization and escapes from a single potential well are examined by G. Litak et al. On the basis of a harmonically driven energy harvesting system of two magnetopiezoelastic oscillators coupled by electric circuit. The authors show that in the system with relative mistuning in the stiffness of the harvesting oscillators, the voltage output depends on frequencies of excitation. Moreover, the total output power versus the frequency of excitation exhibits the typical resonance curve, however due to mistuning the harvesters works mostly in the unsynchronized regime.

M. Popescu and A. Dumitrache study a class of affine nonlinear dynamic systems, but in particular, some applications in control of bilinear systems with the first order nilpotent operator are found. The problem of control is to determine the optimal functions of control which minimizes the quadratic functionals submitted to the differential constraints represented by the considered

dynamic system. In this study, they analyze the problem of control regarding minimizing the quadratic functionals for the class of affine nonlinear systems in the hypothesis when the associated algebra Lie is nilpotent. Additionally, the authors determine the optimal control which corresponds to the nilpotent operator of the first order. The control algorithm is obtained by minimization of energy of the considered nonlinear systems.

Vibrations of offset printing presses is a serious problem that causes many difficulties while printing. The most common are difficulties with obtaining of registers alignment and colors reproduction accuracy. The most important source of that problem lies in construction of printing units that consist of cylinders being in contact excite vibrations. Y. Pyryev and J. Krzyżkowski give an analytical study of such contact vibrations on the basis of a model of chosen offset printing unit. Computer simulations of the system of two second order differential equations are performed, as well as conditions at which the undesired parametric resonance appears are estimated.

Middle ear surgery techniques have enabled to improve hearing destroyed by a disease. Despite of huge improvement in instrumentation and techniques, the results of hearing improvement surgery are still difficult to predict. R. Rusinek et al. present important measurements of vibrations propagated in a human middle ear. Vibrations of these stapes in the case of the intact ossicular chain, after cement incus, rebuilding and incus interpositions are mutually compared. In this aim, a new approach of ossicles vibrations observation is introduced in order to complete information obtained from classical approach which is based on the transfer function. Measurements of ossicular chain's vibrations are performed on fresh human temporal bone specimen using the laser doppler vibrometer. Performing classical research, the extended analysis with the recurrence plots technique is carefully done.

A three degrees of freedom auto-parametric system with limited power supply is investigated numerically by D. Sado et al. The system consists of a mass which is hung on a damper-spring element and two connected by shape memory alloys spring pendulums. A polynomial constitutive model is assumed to describe the behavior of the alloy spring. The nonideal source of power adds one degree of freedom increasing to four degrees of freedom of the investigated system. Its equations of motion are solved numerically and some pseudo-elastic effects associated with the martensitic phase transformation are studied. It is shown that in this type of system, one mode of vibrations might excite or damp another mode. In addition, except different kinds of periodic vibrations, there may also appear chaotic vibrations. To identify behavior of the analyzed dynamical system, various techniques such as bifurcation diagrams, time histories, power spectral densities, Poincarè maps and Lyapunov exponents are used.

Paper written by S. Tengler and A. Harlecki deals with a method of dynamics analysis of fire engines. As examples of such engines may serve vehicles with high centre of gravity. Algorithms for generating equations of motion of the investigated dynamical system have been formulated by homogenous transformations and Lagrange equation. The model consists of a system of interconnected rigid bodies forming an open kinematic chain. Road maneuvers such as a lane change and negotiating a circular track are presented in simulations of a car losing its stability.

Finally, it should be emphasized that the selected papers are oriented toward modeling and controlling of mechanical and biomechanical systems. They have been reviewed by two independent referees to satisfy the journal's standards.

In addition, J. Awrejcewicz greatly appreciates a kind invitation of Professor Zaihua Wang to publish a few of the recommended papers within this special subject. Furthermore, a professional help of the TAML's staff in the final production process is acknowledged.

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